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Vol. II. No. III.

BULLETIN

... OF ..

The Chicago Academy of Sciences

The Gross Anatomy of Limnæa Emarginata, Say, Var. Mighelsi, Binney.

.. BY ..

FRANK COLLINS BAKER

Curator of The Chicago Academy of Sciences

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THE GROSS ANATOMY OF LIMNÆA EMARGINATA VARIETY MIGHELSI.—Binney.

BY FRANK COLLINS BAKER.

It was the writer's good fortune some time since to receive a number of living and alcoholic specimens of *Limnæa emarginata* and its variety *mighelsi* from Mr. Olof O. Nylander, of Caribou, Maine, for anatomical investigation. So little is known concerning the anatomy of our American Limnæidæ, it was deemed best to make an exhaustive study of this material. In the anatomical notes which follow, the splendid works of Bronn and Keferstein, Moquin-Tandon and Spengel have formed a safe and exhaustive basis of comparison. Of the many species of Limnæidæ found throughout Europe and America, only a few have been studied anatomically. Among these may be mentioned *L. palustris*, *L. stagnalis*, *L. auricularia*, *L. pereger*, *L. megasoma* and *L. truncatula*. In this paper comparisons are made with all but the last of these species. Generalizations and comparisons with allied genera have been reserved for a future paper, when more shall be known concerning our native species. The reader may make these comparisons for himself by consulting the works mentioned in the bibliography. Dr. Joseph Leidy's work on the American Pulmonata (in Binney, Terr. Moll. U. S., Vol. V.), in which are many beautiful drawings of pulmonate anatomy, will serve admirably as a means of comparison with the air-breathing pulmonates.

The material upon which the following notes are based is unusually fine and abundant, including, besides that already mentioned, some 250 specimens of the shells of *L. emarginata* (typical) from Western New York, collected by Dr. Howard N.

Lyon, and presented by him to The Chicago Academy of Sciences, and 200 specimens of *Limnœa emarginata* var. *mighelsi* from Maine, donated by Mr. Nylander. These two collections show every possible form of this very variable species. In addition to these there are a number of specimens in the collection of the Academy from various localities. The two half-tone plates well illustrate the variability of this species.

About fifty specimens have been dissected and some two hundred and fifty examinations made. Both the typical form of *emarginata* and the variety *mighelsi*, obtained from Maine, have been made a part of this study, but the typical form from New York has not been dissected, as no living or alcoholic specimens were available. The forms from Maine agree in all important details, but whether this would be true of those from New York is uncertain. All of the specimens (with two or three exceptions) were adult, and there was little variation among the different organs. Recent illustrations of the animals of this genus do not, as a rule, show the correct form of the peculiar velum; Lankester's figure 70, in the article Mollusca, Zoological Articles, p. 123, is the only correct recent drawing the writer has seen. The velum varies to some extent among the different species and also among different specimens of the same species, and similar specimens will also vary at different times (see plate III, figures A. B. C.)

In examining this species, marked differences between alcoholic and fresh specimens were observed. The former differed much in color and also in form, the organs being much contracted and distorted. My observations indicate that it is unsafe to describe anatomical details from alcoholic specimens. Accordingly, the notes which follow are taken only from specimens freshly killed by drowning.

The specimens received from Mr. Nylander were kept alive for several months. In captivity the animal is sluggish, remaining for a long time with body and foot contracted and tentacles drooping. The animal is gregarious, forming colonies made up of four or five individuals. During progression the head and velum are raised, the latter moving about in curves. Like all of the Limnæidæ, this species spends long periods out of the water, remaining motionless with its body and head contracted. The first day after the specimens were received several of the

larger forms ate one of their number and also defaced several shells by eating their epidermis. Various kinds of food was given them, some of which they ate with avidity, while other kinds were refused. Lettuce was always eaten with an evident relish; bread, apple and potato was always welcome. Cake, salt cracker, ginger snaps and cheese were given to them, but with one exception these were not eaten at all. One medium-sized specimen seemed ready to eat anything, even cheese. Several empty shells were placed in the water to supply the necessary lime for building up the shells.

The living and alcoholic specimens were from Cross Lake, Portage Lake, Square Lake and Aroostook River, Aroostook County, northeast Maine. Two miles south of Cross Lake inlet this species was found in large numbers in two feet of water. Mr. Nylander reports that "they seemed to feed on the vegetation on the rocks." (See Nautilus, XI, p. 10.)

I wish to acknowledge valuable assistance received from Mr. Olof O. Nylander, for abundant living, alcoholic and dry material; Dr. Howard N. Lyon, Chicago, for a collection of *L. emarginata* (typical); Mr. Frank M. Woodruff, for making the two excellent photographic plates of the shells; Mr. George H. Clapp, Pittsburg, Penn., for dry material; Dr. William H. Dall, U. S. National Museum, Washington, D. C., for notes concerning photographic illustrations and reference to papers for consultation; Mr. P. B. Randolph, Seattle, Wash., for specimens from Alaska; Mr. Charles T. Simpson, U. S. National Museum, Washington, D. C., and Prof. William A. Locy, of Northwestern University, Evanston, Ill., for valuable suggestions.

Limnæa emarginata Say. PLATE I.

Limnæa emarginata SAY, Journ. Phil. Acad. Nat. Sci. II, p. 170 1821; Narr. of Long's exped., p. 263, 1824; Amer. Conch., vi, pl. iv, fig. 1, 1834; BINNEY'S ed., p. 67, 130 and 311, pl. lv, fig. 1, 1858, HALDEMAN, Mon. Lim., p. 10, pl. ii, 1841; DE KAY, Moll. of N. Y., p. 73, pl. iv, fig. 77, 1843; LAPHAM, Trans. Wis. State Agric. Soc., vol. ii, p. 368, 1852; Proc. Phil. Acad. Sci., p. 155, 1860; TRYON, Amer. Jour. Conch., vol. i, p. 252, 1865; Con. Hald. Mon., p. 110, 1870; BINNEY, L. and Fr.-W. Sh. N. Am., p. 51, figs. 75–79, 1865; LEWIS, Bull. Buf. Soc. N. H., vol. ii, p. 135, 1874; INGERSOLL, Rep. Geol. Surv. Terr., p. 406, 1874; AUGHEY, Bull. U. S. Geol. Surv., p. 700, 1877; LATCHFORD, Amer. Nat., vol. xviii, p. 1051, 1884; WALKER, The Nautilus, vol. vi, p. 32, 1892; vol. ix, p. 5, 1895; NYLANDER, The Nautilus, vol. xi, p. 10, 1897.

Limnæa serrata HALDEMAN, Mon. Lim., p. 12, pl. ii, figs. 6, 7, 8, 1841; BINNEY, L. and Fr.-W. Sh. N. Am., p. 52, fig. 78, 1865; TRYON, Amer. Journ. Conch., vol. i, p. 253, 1865; Con. Hald. Mon., p. 110, 1870.

Limnæus ontariensis MUHLFELDT in KUSTER, vide Binney, L. & Fr-W. Sh., p. 51, 1865.

Shell: Of medium size, generally very solid, but varying from thin to thick, globosely ovate, somewhat inflated; color corneous, sometimes very dark, the epidermis plain but sometimes ornamented by longitudinal lighter bands much narrower than the darker band of the ground color of the shell; frequen tly there will be a broad longitudinal band of white on the last whorl, and the sutures are sometimes bordered with white; nucleus small, smooth, rounded, consisting of two chestnut-colored whorls; surface shining, lines of growth numerous, crowded, frequently wrinkled and sometimes crossed by from eight to twelve spiral ridges, giving the surface a malleated aspect; whorls 5–5½, rounded, more or less inflated, the last large and showing a tendency to expand and flare, and also to become shouldered; spire typically sharp and pointed, but in some forms, particularly the young, it is depressed and very globose and obtuse; sutures deeply impressed, sometimes chanelled; aperture roundly ovate, very large, occupying about two-thirds of the length of the shell, rounded below and somewhat narrowed above, expanded, in some specimens very much so, color dark chocolate or brownish; there is sometimes an elevated, white callus just within the outer lip, bordered with dark brown or red; peristome sharp, thin, expanded to a greater or lesser degree, enamelled, white; columella white, with a strong plait in the middle, covered with a white callus which spreads over the parietal wall and emargines the narrow, deep umbilicus; this callus forms a flaring, spreading margin, completely encircling the aperture. The aperture is frequently distorted.

Length,	26.75;	breadth,	16.00;	ap. length,	15.00;	breadth,	9.00	mill.,	N Y.
"	23.00;	"	15.50;	"	14.00;	"	10.50	"	"
"	22.00;	"	14.00;	"	14.00;	"	10.50	"	"
"	19.75;	"	10.50;	"	11.00;	"	7.00	"	"
"	19.00;	"	10.00;	"	10.00;	"	7.00	"	"
"	21.00;	"	11.00;	"	11.00;	"	7.00	"	"
"	18.50;	"	11.50;	"	11.50;	"	8.00	"	"
"	16.00;	"	10.00;	"	10.75;	"	7.00	"	"
"	15.75;	"	10.50;	"	10.75;	"	8.00	"	"
"	18.00;	"	11.50;	"	11.00;	"	7.00	"	"
"	15.00;	"	10.00;	"	10.50;	"	7.25	"	"
"	12 25;	"	9.00;	"	8.50:	"	7.00	"	"
"	16.00;	"	9.50;	"	9.50;	"	6.50	"	"
"	20.00;	"	12.50;	"	13.00;	"	8.50	"	Maine.
"	16.50;	"	10.50;	"	10.00;	"	6.50	"	"
"	11.75;	"	7.75;	"	7.50;	"	4.50	"	"

Distribution: Owasco River, foot of Owasco Lake, Cayuga Co., N. Y.; Hayden's Mills, six miles below Auburn, N. Y.; north end of Owasco Lake (Dr. Howard N. Lyon); first of four lakes, near Madison, Wis., (P. P. Carpenter); Pigeon Lake, Ontario, Canada, (George H. Clapp); Aroostook River, Caribou, Maine, (Olof. O. Nylander, October, 1895); Madison, Wis.; Lake Winnipeg; Owasco Lake, N. Y.; Lake Superior; Otter Tail Creek, Minn., (from Binney, p. 53); Lake Namokin, north of Lake Superior; lakes in the Northwest Territory, State of Maine (Haldman, p. 11); Anticosti Island, Canada, (Latchfield); Macinac Island, Mich., (Walker); Bow River, Nebraska, (Aughey); New England to Washington Territory (Ingersoll); Northern part of Michigan (Walker).

This species is extremely variable, as is well shown in plate I. The extremes of variation are so great that were it not for the abundant intermediate forms they would be declared distinct species. The type form described by Say has a long-spired, graceful shell; from this form we pass by an unbroken series to the short, stumpy form with a low spire and large, more or less spreading aperture. It is a peculiar fact that in this genus many of the species have a long and short spired variety, as is well seen in *L. catascopium* Say and its variety *pinguis* Say, *L. decollata* Mighels, and *L. stagnalis* Linne and their short-spired varieties. This connection can be seen only when a large number of specimens are examined and compared. The short-spired form of *emarginata* connects perfectly with similar forms of the variety *mighelsi*.

The writer was at first inclined to place both *L. catascopium* and *L. decollota* in the synonymy of *emarginata* (in which case it would have to be called *catascopium*, as this name was given three years earlier), but the material at hand of these two species would not permit of such a disposition. They are closely related, however, and future investigation may prove them identical. It is unsafe to base a decision on the shell alone, but rather on an examination of both shell and animal. The genitalia or muscular system may possibly give some tangible characters.

The specimens from Owasco River are generally graceful and long-spired forms, while those from Maine are short-spired and stout, showing a decided tendency toward the variety, and the same may be said of specimens from Madison, Wis. Unfortu-

nately no specimens of the animal of the typical form were available for anatomical study. The writer hopes to be able to present the results of studies of this character in a later paper.

Limnæa emarginata var. mighelsi. W. G. Binney. PLATE II.

Limnæa ampla MIGHELS, Bost. Journ. Nat. Hist., vol. iv, p. 347, pl. xvi, fig. 1, a, b, c (April, 1843), (Preoccupied by Hartmann for *Gulnaria ampla* described in 1842); Proc. Bost. Soc. N. H., vol. i, p. 129, 1843; BINNEY, Proc. Phil. Acad. Sci., p. 330, 1861; WHITEAVES, Can. Nat., vol. viii, p. 112, fig. 11, 1863; MORSE, Terr. Pul. Maine, 1864; BINNEY, L. & Fr. W. Sh. N. A., p. 30, fig. 34, 1865; TRYON, Amer. Journ. Conch., vol. i, p. 247, 1865; Con. Hald. Mon., p. 91, pl. xvi, figs. 6, 7, 8, 1870; LEWIS, Bul. Buf. Soc. N. H., vol. ii, p. 135, 1874; MORSE, Bul. Essex Inst., vol. xii, p. 172, 1880; WALKER, The Nautilus, vol. vi, p. 34, 1892; vol. ix, p. 4, 1895; NYLANDER, The Nautilus, vol. xi, p. 10, 1897; RANDOLPH, The Nautilus, vol. xii, p. 110, 1899; WALKER, The Nautilus, vol. xiv, p. 8, 1900.

Limnæa sumassi BINNEY (non BAIRD) L. & Fr. W. Sh. N. Am., p. 43, fig. 58, 1865; TRYON, Con. Hald. Mon., p. 91, 1870.

Shell: Large, generally rather thin, very globose, suboval, inflated; color horny, olivaceous green or rich chestnut; the epidermis is frequently eaten away by the carbon dioxide (CO_2) in the water, and is sometimes streaked as in *emarginata;* nucleus consisting of one and a half chestnut or wine-colored whorls, smooth and rounded and rapidly increasing in size; surface dull or shining, lines of growth fine, wavy, crowded, crossed by numerous fine, impressed spiral lines, giving the surface a delicate texture like network; this is absent, however, in some specimens; frequently, large specimens have a number of raised spiral ridges as in the typical form, and in very old specimens the last whorl is "humped" in several places; whorls 5–5½, convex, inflated, shouldered, the last very large, flaring and strongly shouldered; spire varying from obtusely conic to flattened and much depressed; sutures strongly impressed, deeply channelled in some strongly shouldered forms; aperture very large, flaring, roundly ovate, occupying from two-thirds to three-quarters of the length of the shell, rounded below, and either rounded or square above when strongly shouldered, color varying from deep chocolate to bluish-white; the elevated callus of typical *emarginata* is sometimes present; peristome sharp, thin, generally not flaring as in the typical form; columella white, with a heavy central plait, covered with a callus, and reflected over the umbilicus, which it emargines;

the columellar callus spreads over the parietal wall; the lower part of the aperture sometimes becomes so distorted that it spreads far beyond the umbilicus. The columellar plait extends clear to the apex, a fact only seen when the shell is cut in sections; this is also true of typical *emarginata*. The juvenile shells are very globose and gracefully rounded, the shouldered whorls only appearing in nearly adult or old individuals.

Length,	15.00;	breadth,	12.00;	apert. length,	10.50;	breadth,	8.50	mill.
"	17.00;	"	12.00;	"	12.00;	"	8 00	"
"	19.50;	"	15.00;	"	13.50;	"	9.50	"
"	19.50;	"	15.50;	"	14.00;	"	10.00	"
"	20.00;	"	15.00;	"	14.00;	"	10.00	"
"	16.00;	"	15.00;	"	12.00;	"	9.50	"
"	25.50;	"	15.50;	"	15.25;	"	11.25	"
"	28.00;	"	18.50;	"	18.50;	"	13.00	"
"	25.00;	"	17.50;	"	17.00;	"	11.50	"
"	25.00;	"	18.00;	"	20.00;	"	12.00	"
"	28.50;	"	19.50;	"	21.00;	"	13.50	"
"	29.50;	"	21.00;	"	21.00;	"	13.00	"
"	27.50;	"	19.50;	"	20.00;	"	12.00	"
"	35.00;	"	22.50;	"	24.00;	"	15.50	"
"	22.50;	"	19.00;	"	17.50;	"	13.50	"
"	25.50;	"	21.00;	"	21.00;	"	15.00	"
"	29.00;	"	23.50;	"	20.00;	"	16.00	"
"	32.00;	"	25.00;	"	24.50;	"	17.50	"
"	35.00;	"	26.00;	"	27.00;	"	17.50	"
"	36.00;	"	29.00;	"	27.00;	"	17.50	"

Distribution: Square Lake inlet, Cross Lake inlet, Aroostook Co., Maine (Olof O. Nylander); Michigan (T. Jensen); Fort Simpson, British America; Isle La Crosse (Binney, p. 31); northern Maine; St. Lawrence River, English River, British America; Hellgate River and Fort Vancouver, Oregon (Tryon in Con. Haldeman, p. 92); Beaver Island, Lake Michigan (B. Walker); Mid Lake, Maine (Morse); Marsh Lake, near Dyea Valley, Alaska (Randolph); Houghton Lake, Roscommon Co., Mich. (Walker); Eagle Lake, Maine (Morse); Brome Lake, Lower Canada (Whiteaves); British America (Binney); Crystal Lake, Benzie County, Mich., (Kirkland vide Walker).

In the variety *mighelsi* variation seems to have reached its limit. Specimens vary from short, oval with moderately depressed spire to very large with short, almost flat spire, and wide, flaring aperture. It is connected perfectly with the short-spired form of *L. emarginata*, as the figures on the plates con-

clusively show. No published figures show the wide range of variation in this species, and the writer trusts that the illustrations of this paper will aid somewhat in the identification of this prolific variety. Unlike some species, this form does not vary according to any particular locality, but the same locality will produce all known variations. A naturalist fond of making species could form not only a large number of species, but several genera. Anatomically the animals show no such variation, but are wonderfully uniform. The surface of the shells vary from perfectly smooth to heavily malleated. The plait on the columella is very strong, and is continued to the apex of the shell, as is well seen in a section.

Specimens recently received from Alaska, sent by Mr. Randolph, are identical with those from Maine, except that they are heavily malleated and show a tendency toward scalariform monstrosity. In some specimens the aperture runs off at a tangent.

ANIMAL: EXTERNAL APPEARANCE.

PLATE III, figures A, B, C.

Color generally blackish or bluish-black, head, tentacles and the greater part of the body flecked with white or yellowish white, giving the surface the appearance of being covered with a superficial bloom when the animal is in motion, as described by Dr. Whitfield for *Limnæa megasoma* (Bull. Amer. Mus. Nat. Hist., Vol. I, p. 30, 1881). Foot broadly rounded before, more acutely behind, very broad and much flattened on the margins; color bluish-black, lighter beneath and where it joins the body, flecked with yellowish white spots; the center of the sole is lighter than the edge. Head and velum rather short, ranging in form from semicircular to very wide, with the laterial ends obtusely pointed, according as the animal is motionless or rapidly progressing; the vela area is very large in this species, and frequently assumes a bilobate form anteriorly. Mantle large and conspicuous, fitting closely to the aperture of the shell, bluish-black, flecked with whitish or yellowish. Tentacles broad, flat, thin, triangular and very large and conspicuous, obtusely pointed at their extremity, blackish flecked with yellowish white. Eyes black, surrounded by a yellowish-white zone, placed on rather large swellings at the inner bases of the tentacles. Respiratory

orifice placed near the posterior angle of the shell; the so-called "siphon" is capable of great expansion, and when taking in air at the surface of the water is sometimes extended to a length of nearly a third of an inch. The pulmonary cavity fills about half of the body whorl, and is colorless and transparent as seen through the shell, where the heart can also be seen pulsating.

Some animals are lighter than others, the extremes of light and dark being very great. The animal in alcohol is almost jet black, and the spots are sometimes scarcely visible. In a freshly-killed specimen the liver is yellowish-white, with bright yellow patches here and there, but in alcoholic specimens it turns brownish, as seen through the transparent mantle; the edge of the latter is greatly thickened and fleshy, and is made up of the following tissues: an outer thin membrane without cell structure (the *cuticle*); an inner layer of columnar, elongated epithelial cells set on end (the *hypodermis* or *epidermis*); several layers of circular and longitudinal muscles and an inner layer of pavement-like cells (*cœlomic epithelium*), with very large nuclei (plate IV, figs. I, J).

INTERNAL ANATOMY.

Digestive System (Plate iv).

Alimentary tract (C). The alimentary tract is similar in general form and structure to the other Pulmonata, differing only in minor details. The mouth (m) is placed at the anterior end of the buccal sac, into which it opens; the buccal sac (P, N) is somewhat pear-shaped when viewed dorsally, and very much so when viewed latterally (P); it is very stout, being composed of strong muscle fibres, and contains the jaw and odontophore (j); the posterior side bears the two buccal or stomato-gastric ganglia (b g); the œsophagus leaves the buccal sac at the dorsal part of the posterior end (o), and passes to the crop in almost a straight line. The buccal sac is bluish in color, and the œsophagus is dark brown or black. Just posterior to the buccal sac the two salivary glands (C, s g) are placed; they are bright yellow in color, irregular or ramose in shape, and are connected with the buccal sac by four ducts (s d) which enter the latter near the œsophagus. A portion of the salivary gland, near one of the ducts, greatly magnified (L x 519), shows a very large number of small blood vessels and tubes, the former appearing black and the latter white.

The region of the stomach is peculiar and was first correctly noted in American Limnæas by Dr. R. P. Whitfield (op. cit) in *Limnæa megasoma*. The œsophagus first enters the crop (C, D, E, s), which is an elliptical organ when viewed from the dorsal side, but is pyriform when seen laterally; the stomach follows, and at first lies between two very muscular organs, the bilobed gizzard, and then widens into the pyloric portion which gradually tapers to the intestine. The crop and stomach are yellowish in color while the gizzard is almost black. The latter organ is very large, about the size of a small pea, and composed of two concavo convex portions, almost surrounding the stomach, as described above. They are more or less elliptical in outline, and their extremities are connected by a number of stout fibres of a silvery luster, precisely as recorded by Dr. Whitfield (op. cit). The interior is hard and wrinkled, and much resembles the gizzard of a fowl. The latter is as hard as a pea, but the crop and stomach are soft and fleshy. A number of gizzards were cut open; in freshly killed specimens, which had been in captivity for several months, the gizzards were empty, while in alcoholic specimens they contained particles of siliceous matter. The figure of the digestive system of *Limnæa megasoma* in Prof. Wetherby's article * shows this gizzard, although its correct relation to the crop and stomach is not mentioned. The walls of the stomach, crop and gizzard are made up of long muscle fibres, resembling closely those figured in J. They are all covered with a network of bloodvessels.

The intestine (I) is very long, and is marked by but one pronounced flexure (K, I); it makes one complete turn after leaving the stomach, then follows the course of the last whorl and a half, bends upon itself, and finds an exit in the anus within the mantle cavity (C, A), not far from the orifice of the vagina. The last part of the intestine is somewhat enlarged to form the rectum (C, R). The liver is very large, filling completely all but the last whorl of the shell, and is dark brown in color. It opens by a number of large ducts into the intestine, and into the pyloric portion of the stomach, and is made up, beneath the epithelial layer, of round liver-cells of varying size, which float in a colorless fluid, the cells being yellowish brown (H). The

* Notes on Some New or Little Known North American Limnæidæ, by A. G. Wetherby (Journ. Cin. Soc. Nat. Hist., Vol. II, 1879, p. 95, fig. 1).

pancreas is well developed, but not conspicuous. The liver is well supplied with blood vessels which ramify in every direction, forming a complicated plexus. A pair of blood vessels, one on each side, supply the œsophagus, stomach, intestine, etc., with blood. The intestine is made up of the usual tissues (epithelial lining, vascular, circular, etc.,) which need not be dwelt upon here.

In general, the alimentary tract agrees with the figures published by European authors. The figure of the general anatomy of *Limnæa stagnalis* in Keferstein (taf. ciii, fig. 7) shows this tract very like that of the present species, except that no division into crop, stomach and gizzard is indicated. Moquin-Tandon's figure (pl. xxxiii, fig. 25) of *Limnæa auricularia* is almost identical, but his figure of *L. stagnalis* (pl. xxxiv, fig. 18) differs in the form of the stomach, which does not show the divisions indicated above.

Dr. Whitfield mentions a gizzard-like body in specimens of *L. stagnalis* from Sodus Bay, Lake Ontario, (Am. Mus. Bull., p. 37) which closely resembles that in *L. megasoma.*

The Jaw or Buccal Plate (Pl. iv, fig. M. P. J).

Only one buccal plate was found, and this the large superior jaw. The lateral jaws found in most of the Limnæidæ were apparently absent.* The single jaw is large, very wide and low, the dorsal margin is gracefully arched and smooth while the ventral margin is roughly serrated, with an irregular central projection. The anterior face is striated, and the color is dark brown, almost black in some specimens. Where the jaw joins the supporting ligament it is much lighter in color than is the cutting edge. The jaw is placed in the upper part of the mouth at the extremity of the buccal sac (P, J).

The Radula (Pl. iv, A. B.).

The odontophore is more or less quadrangular in form when spread out, and is about twice as long as wide. There are about one hundred and thirty rows of teeth, each row corresponding to the formula 35–1–35 (6-14-15–1–15–14–6). The central tooth (c) is long and narrow, unicuspid, with the lower outer angles of

*As the lateral jaws are frequently difficult to make out, the writer desires to qualify this remark by adding that he was unable to find any jaws, save the large superior jaw, in any specimen examined, search for the lateral jaws being carried on very carefully.

the base of attachment much expanded and produced. Lateral teeth with a subquadrate base of attachment, the lower outer angle somewhat produced; reflection large, reaching below the edge of the base of attachment, bicuspid, the inner cusp (mesocone) very large, symmetrically rounded and terminating in a sharp point; the outer cusp (ectocone) very small, rather long and narrow, the extremity rather sharp and in some cases pointed inward toward the inner cusp; in several radulæ (A,2) examined the second lateral had a swelling on the inner side of the inner cusp which probably represented a tendency to form a third cusp (entocone); the intermediate teeth are, for the most part (A, 16, 17, 20, 21), characterized by long and narrow cusps, the base of attachment being short and almost square; they are tri- or penta-cuspid; the teeth first break into tricuspids (16) by the appearance of an inner cusp, which is modified or breaks off from the inner part of the inner cusp, near the distal end; this soon (20) breaks into three cusps, all being at the extreme distal end of the reflection, the outer and inner cusp being of good size with rounded extremities, while the third or middle cusp is very small and sharp or thorn-like; the original outer cusp here breaks into two small, thorn-shaped cusps (20) placed well up on the outer margin; toward the end of the membrane the teeth become very long and narrow, the small inner cusps disappear and the distal ends become 4 or 5-serrate.

A single radula examined (B, 11, 14, 15) had the first intermediate tooth distinctly tricuspid, the endo-, meso and ectocones being as well marked as in the Helices (11). The fourteenth tooth had the outer cusp broken into two short, rounded cusps, placed side by side; the fifteenth tooth had three equal cusps at the distal end of the original inner cusp, while the outer cusp was as in the lateral teeth; all of the other teeth were normal. As an example of the Limnæidæ, the radula was remarkably constant in the form of the teeth.

Genital System (Pl. III, figs. D. E. F. G).

Male organs (E). As in the Limnæidæ generally, the male and female organs are separate (with the exception of the hermaphrodite gland) and open by separate orifices, that of the male being behind the right tentacle and that of the female at the base of the neck, near the pulmonary opening. The penis sack (P. S.) is very large, of great length and large diameter; it is

wide at the exterior opening, but narrow at the end where the penis is attached. The penis (P.) is half the length of the penis sack, very long and slender, with a rounded head, about two and one half times the diameter of the neck of the penis. The penis and penis sack are retracted and protracted by a set of powerful muscles (RM, PSM). There is a long, hair-like flagellum (F) which extends from the head of the penis to the orifice of the penis sack. A nerve starts from the cerebral ganglion (CG) and after extending for a short distance divides, one branch running to the head of the penis and the other innervating the penis sack (PN, PSN). The penis is generally yellowish in color, sometimes very bright, while the penis sack is grayish (in alcohol) or yellowish (living). The muscles are white in color. The vas deferens (VD) extends from the head of the penis to the columella muscle (CM), where it becomes lost in the muscular tissue; it reappears at the opening of the vagina, where it becomes the duct of the prostate (PD); this duct is rather long, very narrow, and enlarges on the side of the vagina into the prostate gland (PR) a cylindrical, fleshy organ, well supplied with blood vessels, and of a yellowish or amber color. Posterior to the cylindrical portion, the prostate becomes very much narrowed and flattened, whitish in color, and near the albuminiparous gland again enlarges into a much folded organ of a grayish color. From this point the hermaphrodite duct passes to the hermaphrodite gland.

Female organs (D. F. G.). The hermaphrodite gland or ovotestis is made up of a number of rounded or lobulated follicles which have the form shown in figure F when greatly enlarged. The gland is yellowish in color. The ovisperm duct or hermaphrodite duct (OD) extends from the lower part of the ovotestis to the albuminiparous gland, from which it divides, one part forming the prostate and the other the uterus. The albuminiparous gland (AL) is large and rounded, of a greenish color, and made up of quadrangular, pentagonal and hexagonal cells (G), with rather thick walls and filled with granular protoplasm, the granules in the center of the cell being very large. The uterus (U) is at first trilobed, then becomes smaller and rounded, then swells into a large, fleshy, cylindrical sac; the vagina (VA) then contracts to form the vestibule or atrium (A) and finds its exit behind the male orifice and near

the respiratory orifice. The uterus and vagina are yellowish in color and the walls of these organs are made up of strong muscular tissue. The spermatheca or receptaculum seminis (S) is elongate-oval in form, of a pearly white color and connected with the vagina by a long, narrow duct (SD), which enters the latter near the cylindrical portion of the prostate, just above the atrium. The vagina is supplied with two stout retractor muscles (VM). A single nerve (VN) supplies the vagina from the right visceral ganglion. All of these organs are well supplied with blood vessels.

In the natural position the ovotestis is folded in the lobes of the liver and is very strongly attached to that organ. In some works a testicle is described for certain species of the Limnæidæ, viz., *L. megasoma* and *Pompholyx leana* var. *solida*, but no such organ could be found in any of the specimens examined, nor is any described in European works.*

Keferstein's figures of the genitalia of *L. stagnalis* (taf. ciii, fig. 8) agrees with that of the present species in a general way, the difference being that that species has no flagellum, the penis sac is shorter, the prostate more bulbous and not cylindrical, and the spermduct enters the atrium lower down. In fact the female genitalia may be said to be longer and more generally cylindrical in the species under discussion than in *L. stagnalis*. Moquin-Tandon's figure (pl. xxxiv, fig. 27) of *L. auricularia* shows the male organ similar, though the penis is not clearly shown and there is no flagellum. The female genitalia is quite different, but this may be because it was drawn from a different position; *L. stagnalis* (pl. xxxiv, fig. 19) is similar to that figured in Keferstein, and shows about the same differences. None of these figures show the innervation of the male and female genitalia. The vas deferens is not shown in Moquin-Tandon's figures as coming directly from the head of the penis, in fact there seems to be no sharp division between the penis and penis sac in the figures of these two species. Lacaze-Duthiers' figure of *L. pereger* (pl. 17, fig. 2) shows the same innervation of male and female genitalia as the present species.

*It is generally conceded that in the androgynous gastropods the ova are borne on the exterior and the spermatozoa on the interior of the individual follicles.

Nervous System (Pl. IV, figs. N, P; pl. V, figs. A, B).

The nervous system is made up of a nervous collar (ganglia) surrounding the œsophagus, just posterior to the radula sac, and a series of nerve cords. The cerebral ganglia lie above the œsophagus and all the other ganglia lie below it.

The *cerebral ganglia* (CG) are situated above or a little to the side of the œsophagus and are joined to each other, to the pedal ganglia and to the pleural ganglia by short, thick commissures. The right cerebral ganglion sends a nerve to the male generative organ which divides before reaching that organ, one branch going to the penis (PNE) and the other, which again subdivides, innervating the penis sac (PSN). The cerebal ganglia also send nerves to the tentacles (NT), optic nerves to eyes (ON), nerves to the front of the head (FN), labial nerves to the region of the mouth (LN), and a pair of nerves to the buccal sac. These latter or cerebral commissures (CC) enlarge on the buccal sac to form the buccal (BG) or stomato-gastric ganglia. These ganglia send out a number of small nerves which innervate the buccal sac and the manducatory organs (pl. IV, figs. N, P). Branches are also sent to the salivary glands.

The *pedal ganglia* (PG) are very large, lie directly beneath the œsophagus, and are connected with the cerebral and pleural ganglia by short, thick commissures. These ganglia send off two sets of nerves of three each, the first, inferior and superior cervical and columellar nerves (IC, SC, CN) to the posterior part, and the second, superior, inferior and central pedal nerves (IP, CP, SP) to the anterior part of the foot. There are several other short, minute nerves whose functions are unknown to the writer. The otocysts (OT) are placed in the posterior part of these ganglia, and are connected with some of the other ganglia by fine nerves.

The *pleural ganglia* (LG) lie below the œsophagus, and are connected by short, thick commissures with the pedal, cerebral and visceral ganglia. They apparently send off no nerve cords.

The *visceral ganglia* (VG) lie behind, a little above the pleural ganglia, and are connected with the latter and the abdominal ganglia by short commissures. The right ganglion sends off a long nerve (v′ right pallial nerve) which innervates the female genital orifice, a portion of the respiratory cavity and

the right posterior part of the mouth. Near the end of this nerve an enlargement forms the olfactory organ or osphradium (OS . A shorter nerve (V, anterior pallial), leaves this ganglion near the one spoken of, and shortly joins a similar one from the abdominal ganglion, the combined nerve passing to the vagina, the anterior part of the mantle and the respiratory cavity.

The left ganglion sends off a single long nerve which innervates the mantle along its sides (L M).

The *abdominal ganglion* (A G), which is really two ganglia fused together, lies behind and somewhat below the visceral ganglia, is connected with the latter by two short, thick commissures, and sends off four nerves. One of these has already been described under the right visceral ganglion. The central nerve (S I) is the longest and innervates the pericardium, aorta, part of the genitalia, the rectum, kidney and respiratory cavity. A somewhat shorter nerve on the right of this (A) furnishes nerve force to the posterior part of the aorta and a part of the genitalia. To the left of the central nerve a small nerve supplies the anterior part of the mantle. The nerves of the abdominal and visceral ganglia also innervate different portions of the digestive system.

In a living specimen the ganglia are of a very bright orange color, but in alcoholic specimens they are yellowish or yellowish white. The eyes are as usual in androgynous Pulmonata. The sclerotic membrane, choroid, cornea, etc., are well developed, and the optic nerve is very large.

In working out the foregoing, Lacaze Duthiers' article in Archiv. de Zool. Exp., has been followed as a guide. The nervous system of the present species may be said to be almost identical with that of *Limnæa pereger* described and figured by Lacaze Duthiers (pl. 17, fig. 2). Spengel's figure of *L. stagnalis* is also the same (taf. xvii, fig. 11), excepting that the nerves to the penis and vagina are not shown. Moquin-Tandon's figures are different, his *Limnæa palustris* (pl. 34, fig. 27) showing a fused condition of the abdominal and visceral ganglia. In his figure of *L. auricularia* the pleural and visceral ganglia appear to be fused and the nerves are insufficiently shown. No figures, excepting Lacaze Duthiers', show the peculiar innervation of the male and female genitalia.

Circulatory System (Pl VI; pl. IV, figs. F, G; pl. III, figs. H, J).

The heart is on the left side of the animal, at the apex of the respiratory cavity, and lies laterally between the œsophagus and the rectum, and not far from the stomach; it is also between the anterior portion of the liver and is bounded on the right by the kidney. The ventricle and auricle lie in a large oblong pericardium (PE, A, V); a large aorta which leaves the ventricle soon divides into two main branches the *aorta cephalica*, which supplies the œsophagus, stomach, intestines, etc., and the *aorta visceralis*, which supplies the liver and hermaphrodite reproductive organs; this branch splits into two main branches (RV, LV), one going to the liver and the other to the sexual organs.

The *aorta cephalica* extends from the ventricle to a point about the middle of the left crop, where it splits into four main branches, two anterior and two posterior, one pair passing down each side of the œsophagus and the other down each side of the intestine and rectum and finally uniting with the branchial plexus (pl. vi, LVO, ILV, G). From the four main branches about the stomach, several large branches are given off, which in turn imbranch, forming an arborescent plexus over the stomach, crop and gizzard. The lateral vessels of the œsophagus and intestine also form plexuses over both of the latter organs, and two large branches are given off for the salivary glands (S). A complicated plexus is formed over the buccal sac (B), and here the lateral vessels send branches to the eyes, tentacles, penis and two large branches to the foot (E, T, F, P). The branch to the penis divides, forming two main branches, which imbranch many times, forming a plexus over that organ.

One branch of the *aorta visceralis* (RV) supplies the hermaphroditic reproductive organs and divides into four main branches on those organs, one branch supplying the ovotestis (OV), another the oviduct and vagina (VA), another the prostate (PR), and still another the receptaculum seminis. All of these branches subdivide many times and form plexuses over these organs.

The second branch of the *aorta visceralis* is very long and supplies the liver (LV). In this organ there are three main branches, each with several smaller branches, which in turn imbranch to form a dense network or plexus (LI).

The mantle is supplied with a plexus of fine bloodvessels which collect the blood into two large veins, and several smaller ones (M) and which finally unite with the branchial artery (BA). There are no veinous capillaries present, the blood flowing freely about the cœlomic cavity and being collected in the two veins, as already explained.

The writer has been unable to find any reference to the two lateral vessels of the œsophagus and intestine in any work, most figures showing but one vessel. These two vessels were found in all the specimens examined in the position shown in the figures. A cross section of the intestine shows these branches to be true lateral vessels, placed very much like the dorsal and ventral vessels in the earthworm (pl. iii, H). Dorsal and ventral branches (BLV, pl. iii.) are given off which imbranch to a most wonderful degree, forming a typical plexus (pl. iii, J; see also pl. iv, F, G). The arteries and veins were almost black in freshly killed specimens, but the blood itself appeared uncolored.

The circulation does not differ materially from that of any of the Pulmonata, and is similar to the descriptions and figures in Keferstein and Leidy, with the exception of the two lateral vessels of the œsophagus and intestine.

Respiratory System (Pl. III, fig. I; pl. VI).

The respiratory cavity or lung occupies nearly half of the last whorl, when dilated (pl. IV, L). It is longer than wide, and is supplied with a network of blood vessels, forming small fossets (pl. III, fig. I). These connect with the branchial artery, which conducts the æriated blood into the auricle and from this organ to the ventricle. The respiratory cavity is situated on the right side of the body and is closed by a lobe of the mantle, which forms a sort of siphon.

This species does not seem to require oxygen frequently, if one can judge by its actions in captivity. Several specimens confined in a large glass of water visited the surface about three times daily.

Renal System (Pl. VI, K, U).

The kidney lies on the right side of the pericardium, and is a long, cylindrical organ with hard, muscular walls. A ureter (U) leaves the posterior end of the kidney and has its exit not far from the anus. The kidney is covered with a plexus of blood

vessels, which open into it in several places, thus allowing the urinary products to mix with the blood. The structure of the kidney is as usual in the Pulmonata.

Muscular System (Pl. III, figs. D, E; pl. IV, figs. O, P, Q).

Besides the columella muscle and the muscular tissue forming the walls of the different organs, there are a number of free muscles of great importance. These are the retractors of the sexual organs and also of the tentacles and buccal organs. The buccal retractors (pl. IV, fig. P, Q) are two in number and are attached to the columella muscle. The retractors of the tentacles (one for each) are rather wide bands, and are also attached posteriorly to the columella muscle (pl. III, O).

The retractors of the genital system are nearly all attached to the diaphragm or floor of the lung. The penis retractor is a long, ribbon-like band of muscle with one end inserted in the base of the penis and the proximal end inserted in the columella muscle. The penis retractor has a short branch, which leaves it about the middle, and is inserted in the upper part of the penis sac by means of a number of small muscles produced by the splitting up of the main muscle. The penis sac is supplied with three protractors, the distal insertions (on the penis sac) splitting once, and these in turn again, making four separate insertions for each muscle. Two muscles are inserted near the lower part, and one near the middle of the penis sac. (Pl. III, RM, PSM).

The vagina is supplied with two retractor muscles, similar in form to those of the penis sac, the distal insertions (on the vagina) being three in number caused by splitting as described for the penis sac, and inserted, one on the lower part and one near the center (pl. III, D, VM).

The retractors of the foot are attached to the columella muscle, as in most spiral shells.

BIBLIOGRAPHY.

The references cited below are only those which the writer has found bearing directly upon the anatomy of Limnæa:

1816. Cuvier, G.—Memoires pour servir a l'historie et á l' anatomie des mollusques. Paris.

1855. Moquin-Tandon, A.—Histoire Naturelle des Mollusques Terrestres et Fluviatiles de France. Paris. 2 volumes and atlas.

1862–66. Keferstein, Wilhelm.—Bronn's Klassen und Ordnungen der Weichthiere; Malacozoa. Leipzic and Heidelburg.

1872. Lacaze Duthiers, Henri de.—Du Systeme Nervoux des Mollusques Gastropodes Pulmones Aquatiques et d'un nouvel organe d'innervation. In Archiv. de Zool. Exp. 1 ser, Vol. 1, pp. 437–500, pl. 17–20. Paris.

1879. Wetherby, A. G.—Notes on Some New or Little Known North American Limnæidæ. In Journ. Cin. Soc. Nat. Hist., Vol. II, p. 95.

1881. Whitfield, R. P.—Description of Limnæa (Bulimnæa) megasoma, Say, with an account of changes produced in the offspring by unfavorable conditions of life. In Bull. Amer. Mus. Nat. Hist., Vol. I, p. 29–37. New York.

1881. Spengel, Dr. J. W.—Die Geruchsorgane und das Nervensystem der Mollusken. In Zeits. fur Wissen. Zool., Vol. 35, pp. 333–409, taf 17–19.

1882. Tryon, Geo. W.—Structural and Systematic Conchology. Vol. I. Philadelphia.

1891. Lankester, E. Ray.—Zoological Articles contributed to the Encyclopædia Brittanica. Article Mollusca, pp. 95–158. Edinburgh and New York.

1894. Pilsbry, Henry A.—Guide to the Study of Helices. Manual of Conchology, Vol. 9, second series. Philadelphia. (The terms *endocone*, *mesocone*, *ectocone*, *atrium*, etc., have been taken from this work and used for the corresponding organs in Limnæa).

EXPLANATION OF PLATE I.

A. *Limnæa emarginata* SAY, from Owasco Lake, Cayuga Co., N. Y., showing variation from the long to the short-spired form. (Dr. H. N. Lyon.)

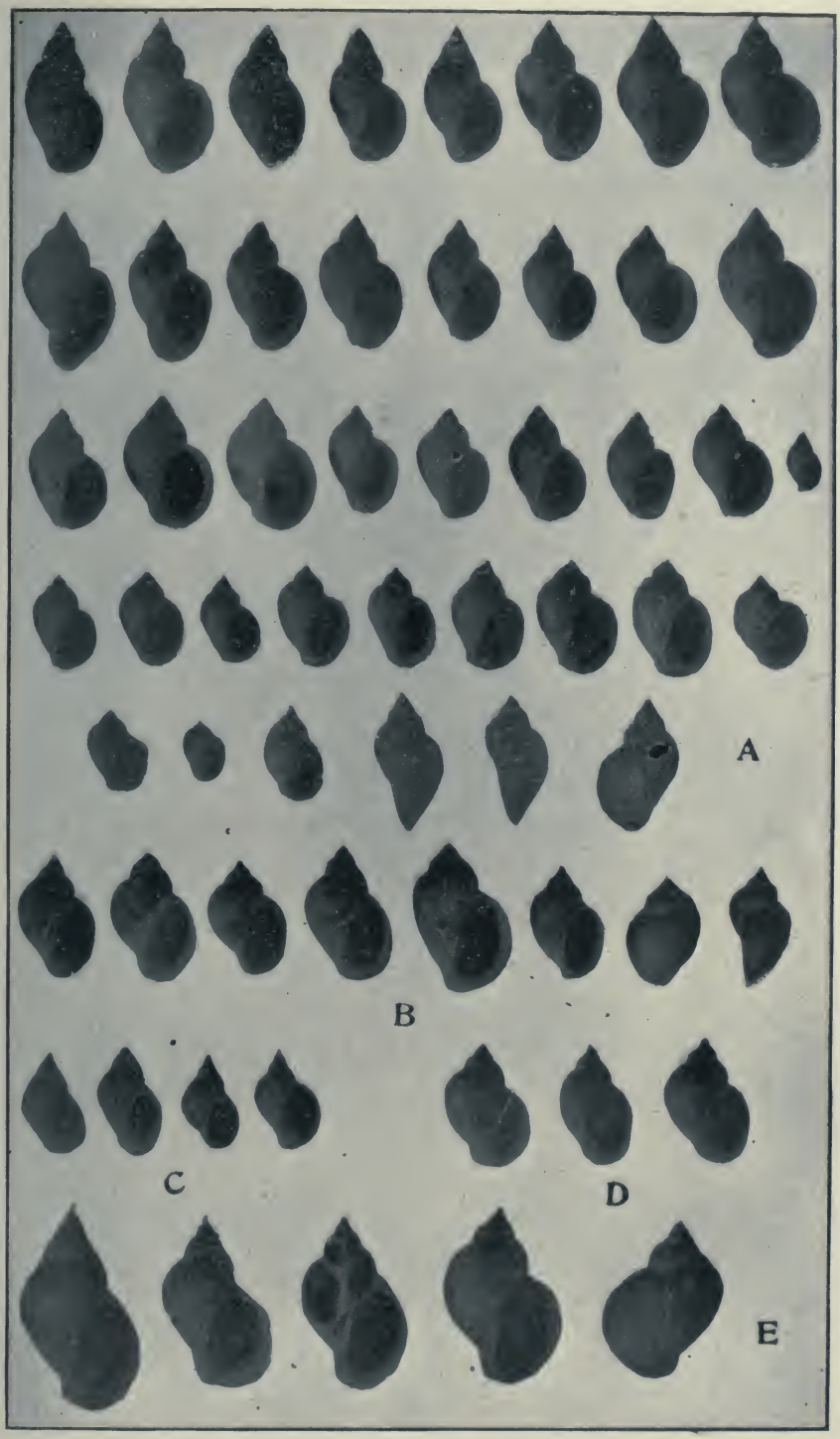
B. The same from Aroostook River, Caribou, Aroostook Co., Maine, (O. F. Nylander.)

C. The same from Pigeon Lake, Ontario Province, Canada. (Geo. H. Clapp.)

D. The same from First of Four Lakes, Madison, Wisconsin. (P. P. Carpenter.)

E. The same from Owasco River, Cayuga Co., N. Y. (Dr. H. N. Lyon.)

PLATE I.



EXPLANATION OF PLATE II.

Showing variation of shells of *Limnæa emarginata* Say, variety *mighels*, Binney, from the form with elevated spire and narrow aperture to that with a short spire and wide, spreading aperture. All from Cross Lake, Aroostook Co., Maine. (Olof O. Nylander.)

PLATE II.

EXPLANATION OF PLATE III.

A. B. C. Animal of *Limnæa emarginata* SAY, var. *mighels*, Binney. A, from above; B, from below; C, from the right side, showing extended velum.

D. Genitalia (principally female).
A, atrium or vestibule of vagina; AL, albuminiparous gland; O, ovotestis; OD, ovisperm duct; PD, duct of prostate gland; PR, prostate; S, spermatheca or receptaculum seminis; SD, duct of spermatheca; V, vagina; VM, retractor muscles of vagina; U, uterus.

E. Male organs.
CG, cerebral ganglion; CM, columella muscle; F, flagellum; P, penis; PG, pleural ganglion; PN, nerve to penis; PS, penis sac; PSM, penis sac protractor muscles; PSN, penis sac nerve; RM, retractor muscle of penis; VD, vas deferens; G, visceral ganglion; VN, nerve to vagina.

F. Portion of ovotestis, showing blood vessels (x 519).

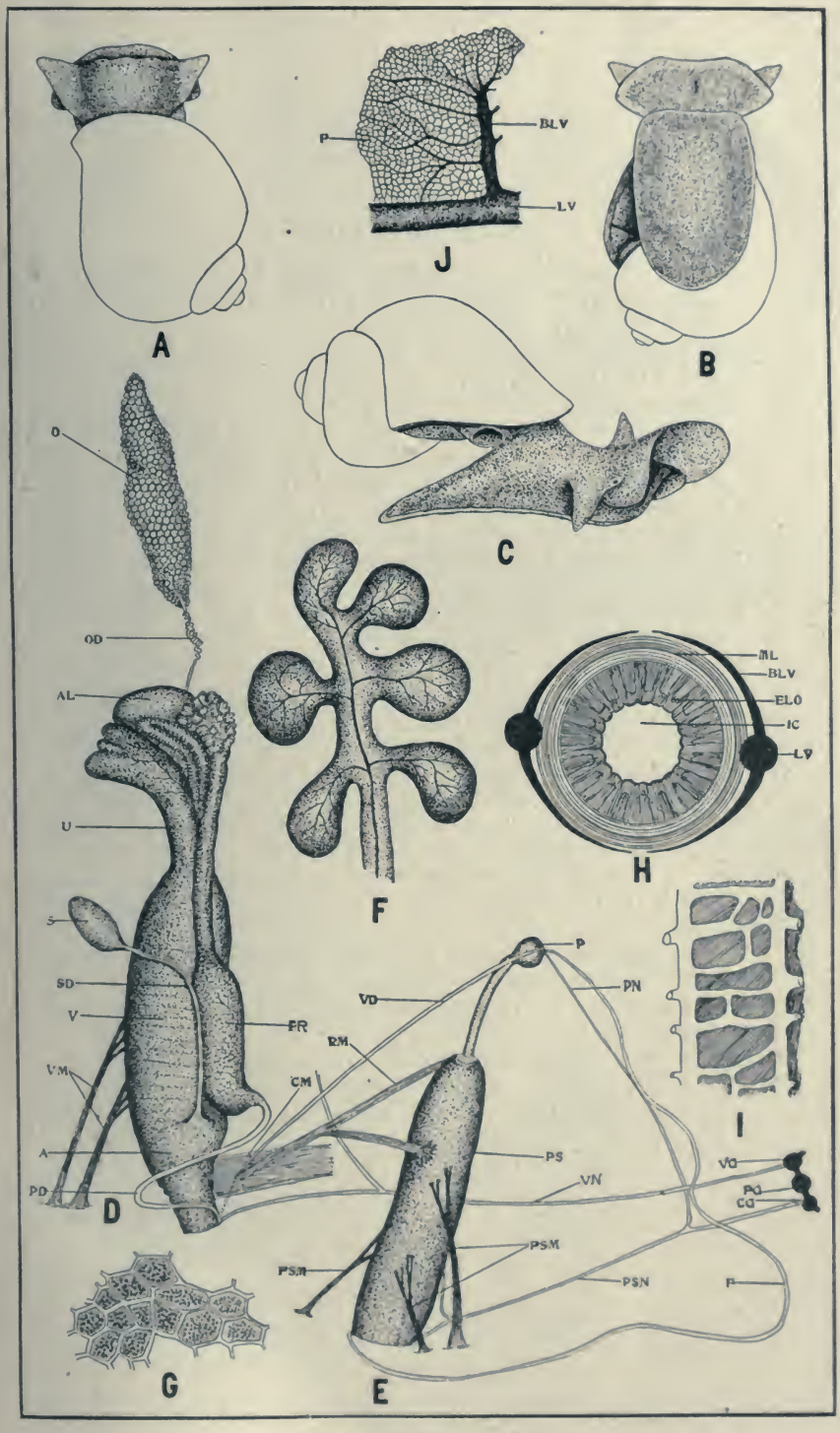
G. Cells from the albuminiparous gland (x 519).

H. Diagramatic section of intestine; BLV, branch of lateral blood vessel; ELO, epithelial layer of œsophagus; IC, intestinal cavity: LV, lateral blood vessel; ML, muscular layer of œsophagus.

I. Portion of lung, showing two main vessels and several connective vessels (x 519).

J. Portion of lateral blood vessel with one branch with its connective plexus (x 519).

PLATE III



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EXPLANATION OF PLATE 4V.

A. Radula; C, central tooth; 1, first lateral; 2, second lateral; 10, tenth lateral; 16, transition tooth; 17, 20, 21, 30, marginal teeth; 32, 34, extreme marginals.

B. Radula of another specimen; 11, eleventh lateral; 14, transition tooth; 15, first marginal.

C. Digestive system, seen from above, the intestine and liver turned to the right. The whole system is dissected and spread out (see K); A, anus; BS, buccal sac; BV, blood vessel of liver; G, gizzard; I, intestine; L, liver; LV, lateral blood vessel; M, mouth; O, œsophagus; P, pyloris; R, rectum; S, crop; SG, salivary gland; SD, duct of salivary gland.

D. Stomach, crop and gizzard from below; lettering same as C.

E. Stomach, crop and gizzard from the left side; lettering as in C.

F. Portion of intestine showing lateral blood vessel, one on each side (x 100).

G. Portion of intestine showing lateral vessel and three branches (x 200).

H. Cells from the liver (x 519).

I. Cœlomic epithelial cells of mantle (x 519).

J. Connective muscle cells from mantle (x 519).

K. Limnæa mighelsi partly dissected to show natural position of intestine. L, liver; I, intestine; ⟶ indicates the natural course of the intestine from mouth to anus.

L. Portion of salivary gland near duct, showing numerous blood vessels (x 519).

M. Jaw.

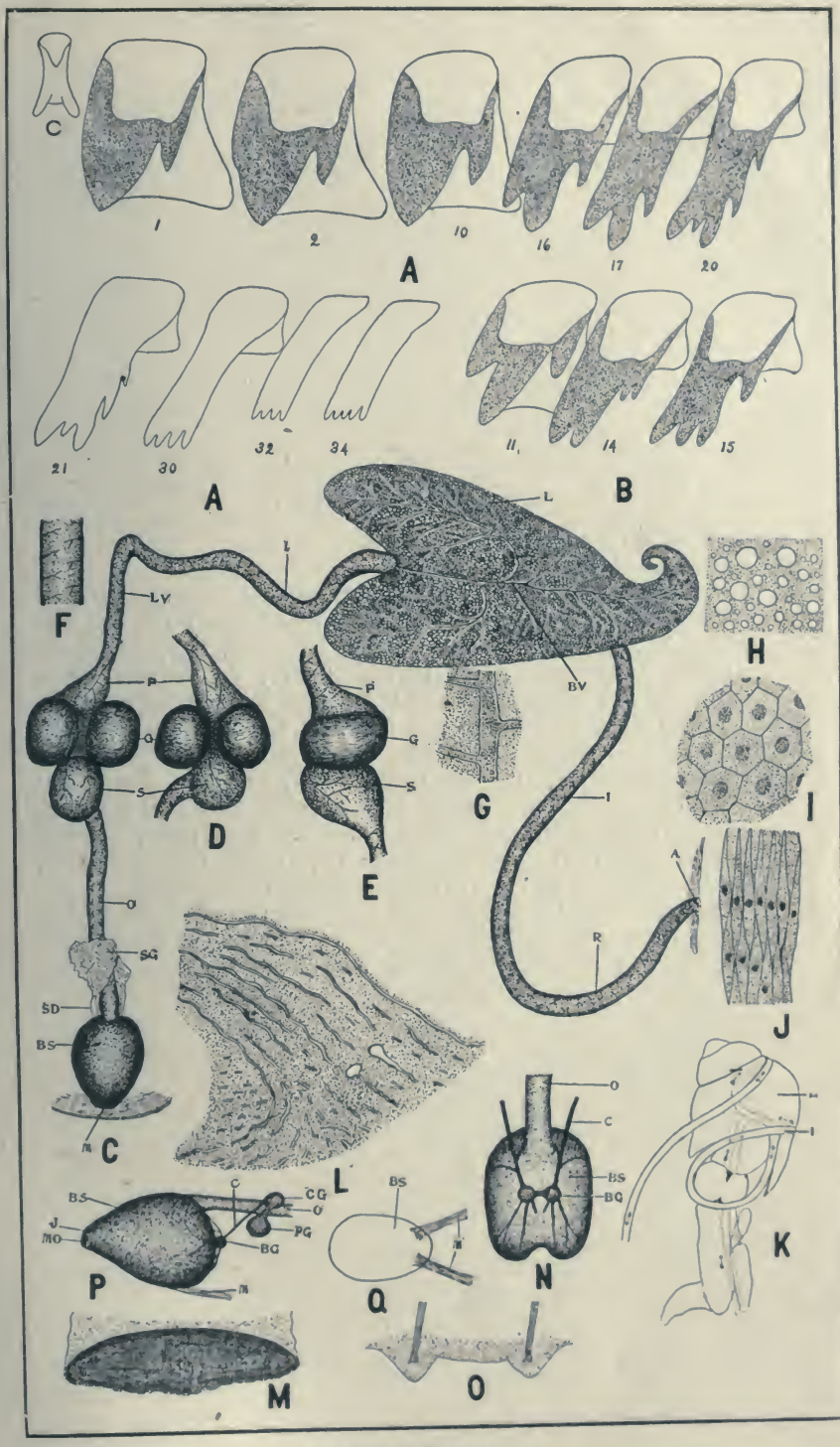
N. Buccal sac, viewed from the posterior end, the œsophagus turned forward; BG, buccal ganglion of left side; BS, buccal sac; C, connective nerve between buccal ganglion and cerebral ganglion; O, œsophagus.

O. Tentacles, showing retractor muscles.

P. Buccal sac, viewed from the left side. BG, BS, C and O as in fig. N; CG, cerebral ganglion; J, jaw; M, retractor muscle; MO, mouth; PG, pedal ganglion.

Q. Buccal sac viewed from below and turned forward; lettering as in P.

PLATE IV.



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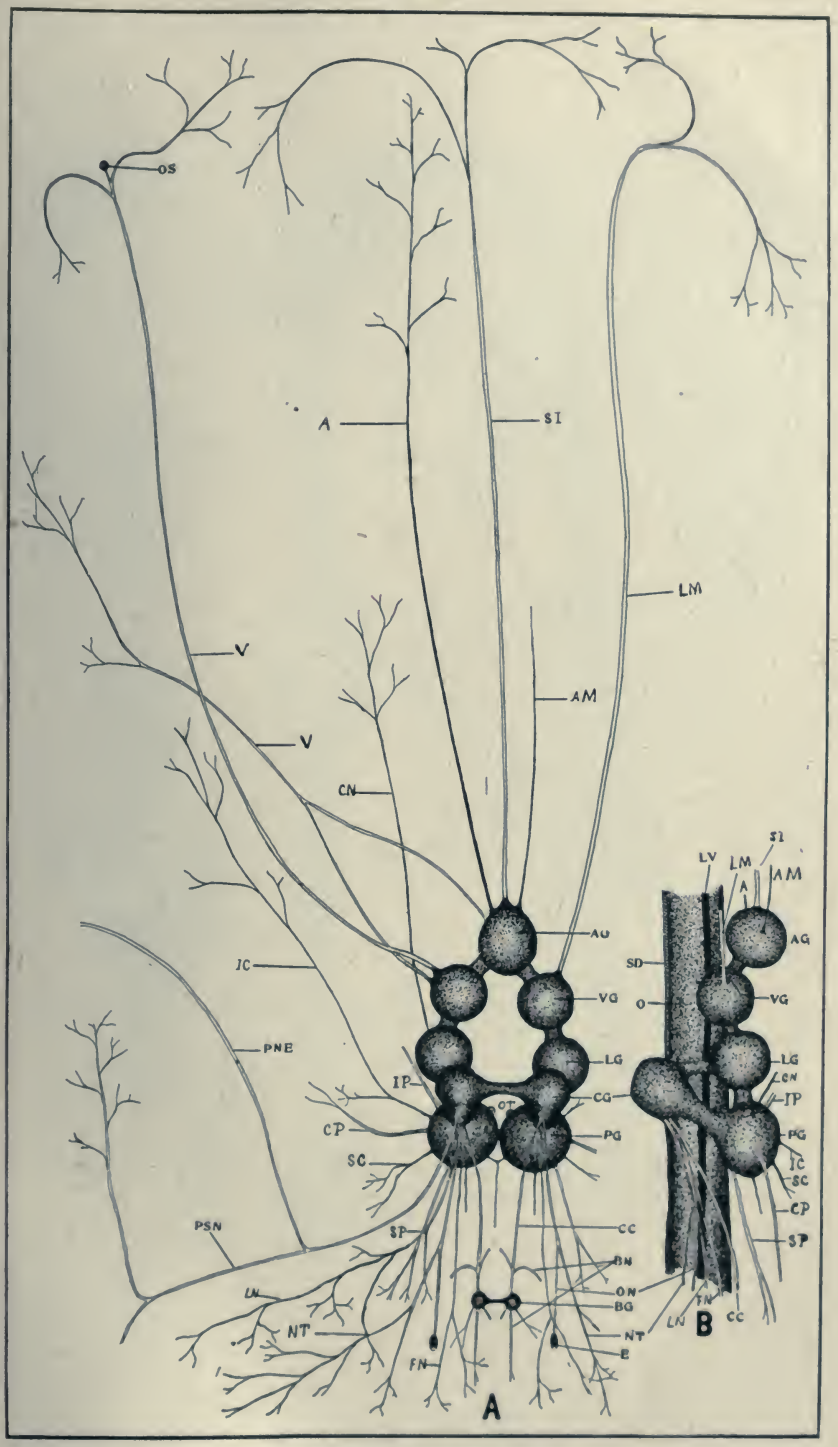
EXPLANATION OF PLATE V.

A. Nervous system viewed from above.
B. Same viewed from the left side.
A. Aortic nerve. AG, abdominal ganglion; AM, anterior mantle nerve; BG, buccal ganglion; BN, buccal nerves; CC, cerebro-buccal connective; CG, cerebral ganglion; CN, columella nerve; CP, central pedal nerve; E, eye; FN, frontal nerve; IP, inferior pedal nerve; IC, inferior cervical nerve; LG, pleural ganglion; LN, labial nerve; LV, lateral bloodvessel; LM, lateral mantle nerve; NT, tentacular nerve; O, œsophagus; ON, optic nerve; OS, osphradium; OT, otocysts; PG, pedal ganglion; PNE, penis nerve; PSN, nerve to penis sac; SD, duct of salivary gland; SC, superior cervical nerve; SP, superior pedal nerve; SI, genital nerve; VG, visceral ganglion; V, anterior pallial nerve; V, right pallial nerve.

The left visceral ganglion is a trifle too large in the figures. Only the nerves in the right side are shown for a part of the nervous system, where they are duplicated on the opposite side.

PLATE V.



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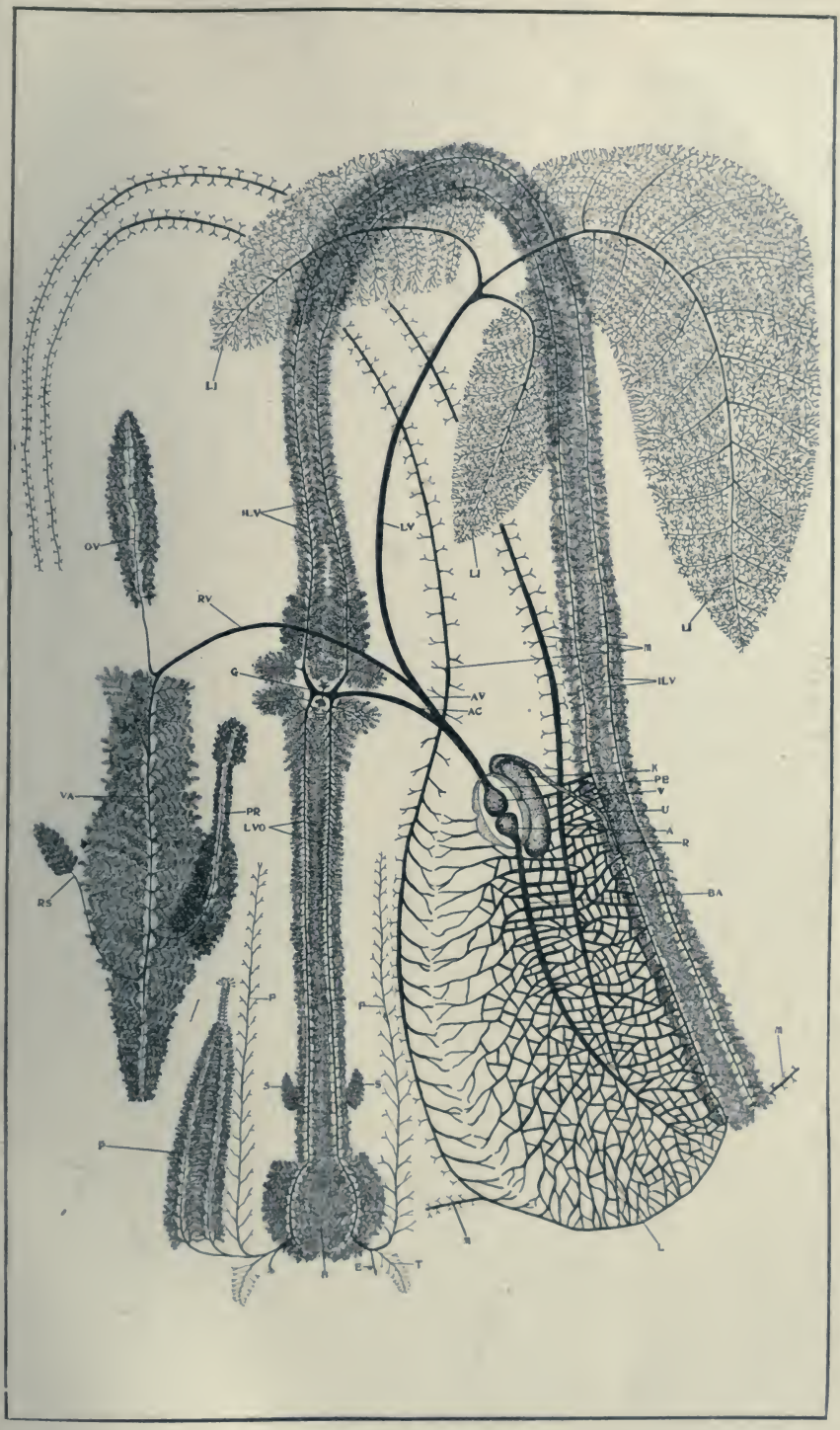
EXPLANATION OF PLATE VI.

A. Auricle.
AC. Aorta cephalica.
AV. Aorta visceralis.
B. Plexus covering buccal sac.
BA. Branchial artery.
E. Vein to eye.
F. Pedal artery.
G. Artery from aorta cephalica which sends branches to gizzard, stomach, intestine, etc.
ILV. Lateral vessels of intestine.
K. Kidney.
L. Lung.
LI. Blood vessels of liver.
LV. Artery from aorta visceralis to liver.
LVO. Lateral vessels of œsophagus.
M. Mantle veins.
OV. Vessels of ovotestis.
P. Vessels of penis sac and penis.
PE. Pericardium, cut open.
PR. Vessel of prostate gland.
R. Rectum.
RS. Vessel of spermatheca.
RV. Artery to reproductive organs, from aorta visceralis.
S. Vessels of salivary glands.
T. Vessel of tentacle.
U. Ureter.
V. Ventricle.
VA. Vessels of vagina.

This plate shows the circulatory system as seen from above, the heart, lung and rectum turned over to the left (hence the lower side is presented), as well as the liver. The arteries and their vessels are represented as though dissected and spread out to show the plexus which they form. The branch of the aorta visceralis, which supplies the generative organs, is represented considerably longer in the figure than it is in nature, this lengthening being necessary to show the branches of the circulatory system.



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